INDOOR AIR QUALITY ASSESSMENT

Framingham High School
115 A Street
Framingham, Massachusetts 01701

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
December 2005

Background/Introduction

At the request of parents, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality concerns at Framingham High School (FHS), 115 A Street, Framingham, Massachusetts. Complaints of poor airflow, temperature control and concerns related to construction/renovations prompted the request. On October 13, 2005, Cory Holmes, an Environmental Analyst for CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of the building that focused on renovation/construction and chemical storage issues. A report with recommendations to improve IAQ conditions identified during the October 13, 2005 assessment of renovation activities was released (MDPH, 2005). Mr. Holmes returned on November 3, 2005 to conduct a general IAQ assessment. The November 3, 2005 results are the subject of this report.

At the time of the November 3, 2005 visit, renovations were complete in wings A through D; construction/renovation activities were on-going in the auditorium and wings E and F. As stated in the previous assessment, the project began in the summer of 2002 and is scheduled for completion in January of 2005.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses high school students grades 9-12 with a student population of approximately 2060 and a staff of approximately 220. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) parts of air in thirteen of fifty-five areas surveyed, indicating adequate ventilation in the majority of areas surveyed during the assessment. However, several classrooms in each of the wings surveyed (A through D/Table 1) had carbon dioxide levels measured above 800 ppm, which can indicate a lack of air exchange via the mechanical ventilation system.

Mechanical ventilation is provided by rooftop air-handling units (AHUs) equipped with high efficiency pleated air filters (Pictures 1 and 2). Fresh air is continuously distributed via ceiling-mounted air diffusers (Picture 3) and ducted back to AHUs via ceiling or wall-mounted return vents (Picture 4). In some cases, the location of exhaust vents can limit exhaust efficiency. In several classrooms, exhaust vents are located above hallway doors (Picture 5). When classroom doors are open, exhaust vents will tend to draw air from both the hallway and the classroom, reducing the effectiveness of the exhaust vent to remove common environmental pollutants. In science classrooms, general exhaust ventilation is designed to be provided by the continuous operation of laboratory hoods. The supply vent in science classroom C-219 was located directly above the laboratory hood (Picture 6). In this configuration the laboratory hood exhaust draws supply ventilation directly from the source, thereby preventing optimal air circulation.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The mechanical ventilation systems at FHS were reportedly balanced prior to occupancy of the 2005-2006 school year.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperature measurements ranged from 70° F to 75° F, which were within or very close the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Although temperatures were within the recommended comfort range, temperature control complaints from occupants were expressed to MDPH staff during the assessment. MDPH staff encouraged staff to share these complaints with the facilities department in order for their HVAC vendor to make adjustments. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 30 to 36 percent, which was below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A few areas had water-damaged ceiling tiles (Picture 6), which can indicate leaks from either the roof or plumbing system. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Several classrooms had a number of plants. Moistened plant soil and drip pans can be a source of mold growth. Plants should be equipped with drip pans. The absence of drip pans can lead to water pooling and mold growth on windowsills. Plants are also a source of pollen. Plants should be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the classroom.

Several rooms contained aquariums and terrariums. Aquariums and terrariums should be properly maintained to prevent bacterial growth, mold growth and nuisance odors.

Other IAQ Evaluations

During the initial visit on October 13, 2005, MDPH staff identified and addressed several issues in the chemical storage area (MDPH, 2005). Several other conditions that can also affect indoor air quality were noted during this most recent assessment. A number of classrooms also contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

In some classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

In addition, dust and other materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation. Accumulation of wood dust was observed in the library shelves near the windows (Picture 7). Dust can be irritating to eyes, nose and respiratory tract.

A few classrooms had missing/dislodged ceiling tiles or items hanging from ceiling tiles. The movement or damage to ceiling tiles can release accumulated dirt, dust and particulates that accumulate in the ceiling plenum into occupied areas.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 8). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas TVOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Implement MDPH recommendations from previous IAQ assessment (MDPH, 2005).
2. Continue to operate both supply and exhaust ventilation continuously during periods of school occupancy to maximize air exchange. Consult the school's heating, ventilation

and air conditioning (HVAC) engineer concerning an increase in the introduction of outside air in areas indicated in Table 1.

3. Continue working with HVAC contractor to resolve temperature/ventilation issues. Faculty and staff are encouraged to report any complaints concerning temperature control/preventive maintenance issues to the facilities department via the main office or alternate reporting procedure.
4. Consider having the ventilation system balanced by an HVAC engineer every five years (SMACNA, 1994).
5. Relocate supply vent in classroom C-219 to prevent short-circuiting from laboratory hood exhaust.
6. Close classroom doors to maximize air exchange.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Ensure roof/plumbing leaks are repaired and replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
9. Clean/maintain aquariums/terrariums to prevent mold/bacterial growth and associated odors.

10. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

11. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

12. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation**.** Consider replacing with alternative "glides" (Picture 9).

13. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html.

14. Refer to resource manual and other related indoor air quality documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at: http://mass.gov/dph/indoor_air

References

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

MDPH. 2005. Indoor Air Quality Assessment. Framingham High School, Framingham, MA. Massachusetts Department of Public Health, Center for Environmental Health, Boston, MA. October, 2005.

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

NIOSH. 1998. Latex Allergy A Prevention. National Institute for Occupational Safety and Health, Atlanta, GA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC. Http://www.sbaa.org/html/sbaa_mlatex.html

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

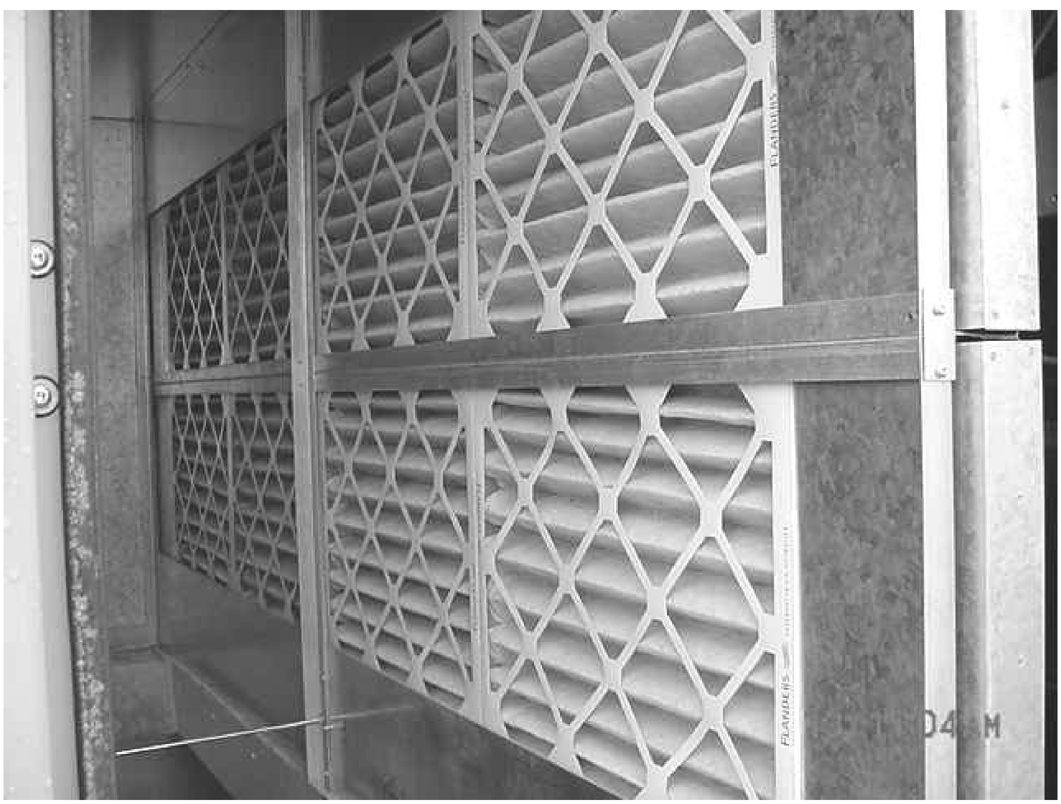
SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

Picture 1

Rooftop Air Handling Unit (AHU)

Picture 2



Bank of High-Efficiency Pleated Air Filters in Rooftop AHU

Picture 3

Ceiling-Mounted Supply Vent

Picture 4

Ceiling-Mounted Return Vent, Note Proximity to Open Classroom Door

Picture 5

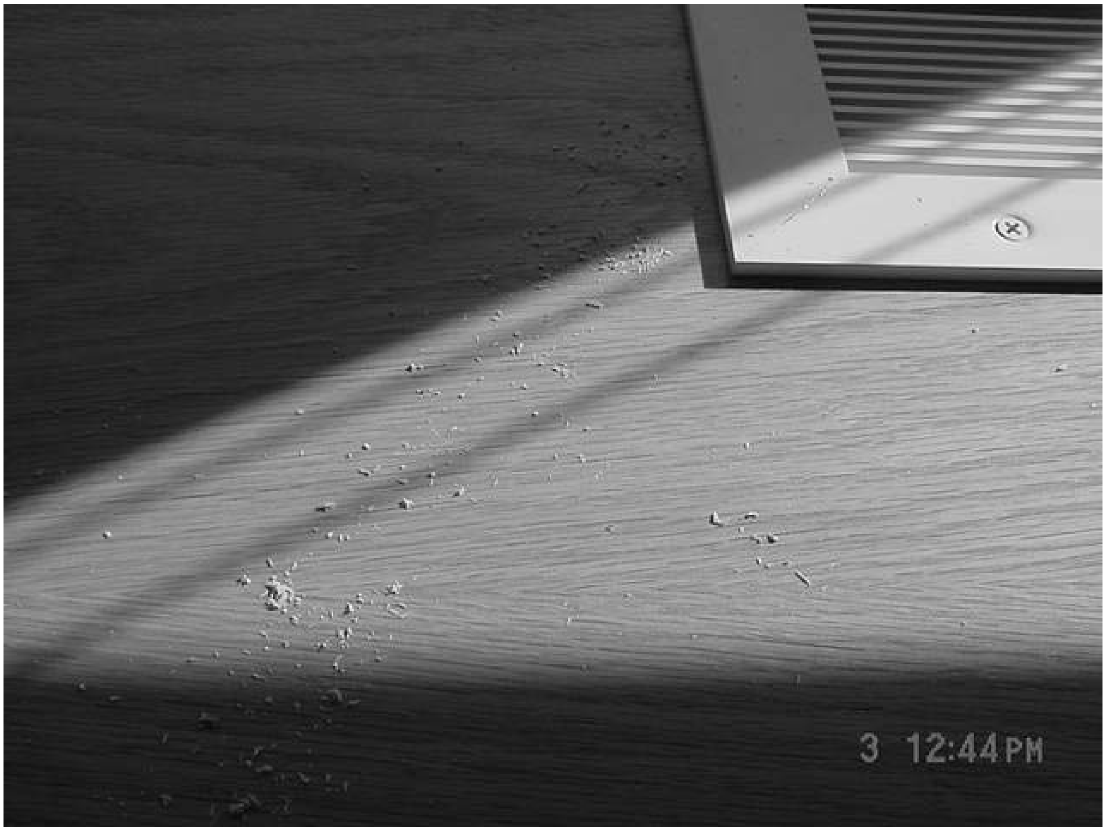
supply vent

Proximity of Supply Vent to Lab Hood Exhaust System in Classroom C-219

Picture 6

Water Damaged Ceiling Tile

Picture 7

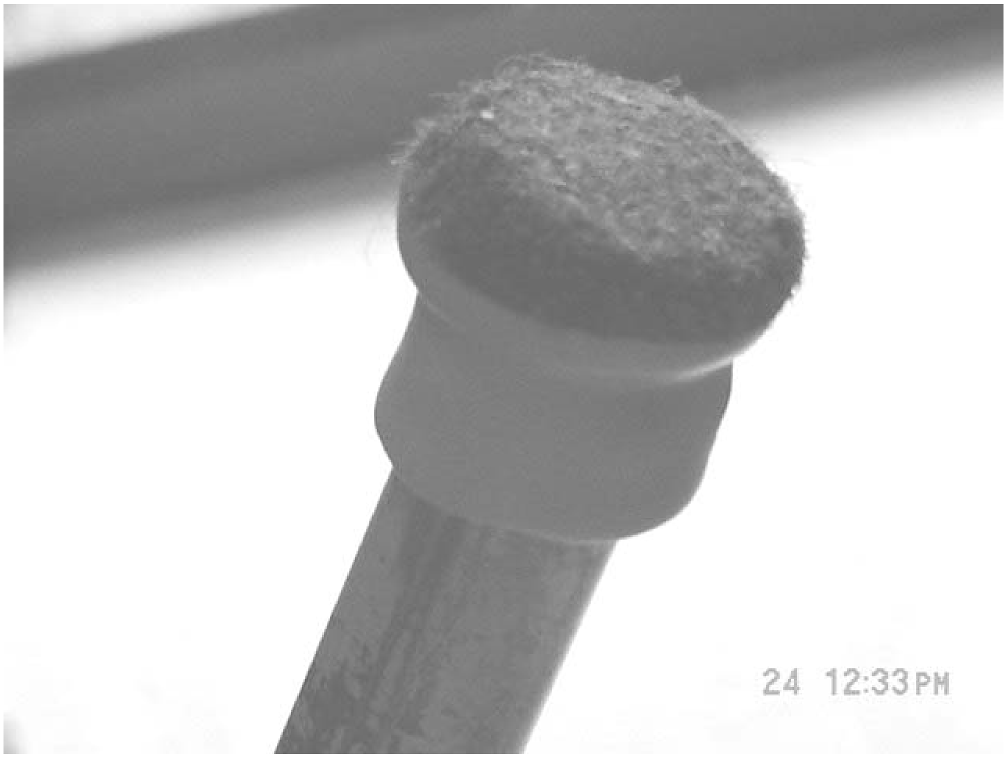


Wood Dust on Library Bookshelves Near Windows

Picture 8

Tennis Balls on Chair Legs

Picture 9



"Glides" for Chair Legs that can be used as an Alternative to Tennis Balls

TABLE 1

Indoor Air Test Results – Framingham High School, Framingham, MA – November 3, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background	391	58	34					Sunny, scattered clouds, blustery-gusts up to 40 mph
A114	780	71	35	19	Y	Y	Y	DO, DEM
A116	762	71	34	3	Y	Y	Y	
A118	766	71	35	16	Y	Y	Y	Plants, DO, DEM
A119	1008	72	35	26	Y	Y	Y	Accumulated items
A117	724	70	33	18	Y	Y	Y	DEM
A215	1066	71	35	25	Y	Y	Y	2 CT, inactive wasps nest, dislodged CT (2), Items hanging from CTs, DEM, DO
A216	617	73	32	10	Y	Y	Y	DEM
A213	674	71	31	3	Y	Y	Y	Aquarium, DO, 15 occupants gone 30 min
A212	550	72	32	22	Y	Y	Y	DO, DEM

*** ppm = parts per million parts of air, CT = ceiling tile**
PF = personal fan, DO = door open, DEM = dry erase materials
TB = tennis balls, WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Framingham High School, Framingham, MA – November 3, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
A209	674	72	31	19	Y	Y	Y	DO, DEM
B203	915	72	32	20	Y	Y	Y	DEM, DO, PF
B204	790	73	33	21	Y	Y	Y	Lab hood exhaust
B205	783	72	32	15	Y	Y	Y	DO, DEM
B207	722	71	32	22	Y	Y	Y	DO, PF, DEM
B208	797	72	32	22	Y	Y	Y	DO, lab hood exhaust, empty fish tank, DEM
B209	1086	72	34	22	Y	Y	Y	DO, DEM, TB
B210	923	73	33	19	Y	Y	Y	DO, 4 aquariums, plants, DEM
B211	875	73	33	15	Y	Y	Y	DO, DEM
C215	496	71	30	0	Y	Y	Y	DO, lab hood exhaust, DEM
C216	646	72	31	16	Y	Y	Y	DO, plants, fish tank, DEM

*** ppm = parts per million parts of air, CT = ceiling tile**
PF = personal fan, DO = door open, DEM = dry erase materials
TB = tennis balls, WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Framingham High School, Framingham, MA – November 3, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
C218	715	74	32	15	Y	Y	Y	Aquarium, DEM
C219	639	71	32		Y	Y	Y	Supply vent near lab hood exhaust
C207	774	72	33	1	Y	Y	Y	20 occupants gone 5 mins, DEM, PF, DO
C208 sewing	773	73	33	19	Y	Y	Y	DO, DEM
C205	1175	73	35	2	Y	Y	Y	26 occupants gone 7 mins, DO, DEM
C203	698	72	33	2	Y	Y	Y	DO, 16 occupants gone 5 mins, DEM
C204 cooking	645	74	34	17	Y	Y	Y	Local exhaust fan-on, DEM
C201	734	73	32	13	Y	Y	Y	DO, DEM
SPED office	500	72	30	5	Y	Y	Y	
D209	795	73	34	19	Y	Y	Y	DO, TB, PF
D206	562	73	31	0	Y	Y	Y	DO, TB, items hang from CTs, occupants at lunch, DEM

*** ppm = parts per million parts of air, CT = ceiling tile**
PF = personal fan, DO = door open, DEM = dry erase materials
TB = tennis balls, WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Framingham High School, Framingham, MA – November 3, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
D207	538	72	31	16	Y	Y	Y	Windows open, plants
B101	954	72	34	21	Y	Y	Y	PF, DEM
B103	560	72	32	1	Y	Y	Y	DO, DEM, occupants gone 15 mins
B102	786	72	34	17	Y	Y	Y	Plants, DEM, PF
B105	950	73	35	2	Y	Y	Y	19 occupants gone 1 min, DEM
B106	640	72	32	6	Y	Y	Y	DO, plants, PF, terrarium, items hang from CT
B107	857	73	34	0	Y	Y	Y	~24 occupants at lunch
B108	784	73	34	19	Y	Y	Y	Science experiments-burners on, WD CT near lab hood
C115	1283	75	36	17	Y	Y	Y	Science experiments-burners on, DEM, items hang from CTs
C116	798	75	33	21	Y	Y	Y	Science experiments-burners on, DO, DEM
C119	643	73	34	7	Y	Y	Y	Science experiments-burners on, windows open, DO

*** ppm = parts per million parts of air, CT = ceiling tile**
PF = personal fan, DO = door open, DEM = dry erase materials
TB = tennis balls, WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Framingham High School, Framingham, MA – November 3, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
C118	678	74	33	13	Y	Y	Y	DO, DEM
C107	963	73	34	5	Y	Y	Y	DEM
D112	888	73	35	10	Y	Y	Y	Upholstered furniture, DEM
D110	616	72	32	1	Y	Y	Y	Photocopier, DEM
Cafeteria	772	73	33	~300	Y	Y	Y	
Medical Suite	609	74	31	7	Y	Y	Y	
Guidance Suite	705	73	32	2	Y	Y	Y	DO
Library Circulation Desk	522	73	31	8	Y	Y	Y	
Library Computer Lab	511	73	30	17	Y	Y	Y	DO
Library Office A102 D	521	72	30	0	N	Y	Y	Plants

*** ppm = parts per million parts of air, CT = ceiling tile**
PF = personal fan, DO = door open, DEM = dry erase materials
TB = tennis balls, WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Framingham High School, Framingham, MA – November 3, 2005

Location	Carbon Dioxide (*ppm)	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Library A/V Office	445	72	30	2	Y	Y	Y	Plants
Library Office A 106	490	72	31	1	N	Y	Y	
Lower Level Library	500	73	32	0	Y	Y	Y	Saw dust on shelves near windows

*** ppm = parts per million parts of air, CT = ceiling tile**
PF = personal fan, DO = door open, DEM = dry erase materials
TB = tennis balls, WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%